R E P O R T R E S U M E S

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A TOOL FOR INDEPENDENT STUDY IN BIOLOGY.

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IN THE BIOLOGICAL SCIENCES DEPARTMENT OF SACRAMENTO CITY COLLEGE, EMPHASIS HAS BEEN PLACED ON A TYPE OF INDEPENDENT STUDY INVOLVING SELECTION, DESIGN, PERFORMANCE, AND REPORTING OF AN EXPERIMENT TO EVALUATE AN HYPOTHESIS FORMULATED BY THE STUDENT CONCERNING A TOPIC OF HIS SELECTION. THE FACULTY HAS DEVELOPED A PROJECT SELECTION FORM, WITH DIRECTIONS TO THE STUDENT CONCERNING TITLE OF PROJECT, REASON FOR SELECTION, HYPOTHESIS, SUBJECTS, VARIABLES, CONTROL GROUPS, TEST GROUPS, REFERENCES, AND EQUIPMENT. USE OF THE FORM HAS BEEN VALUABLE IN (1) INCREASING EFFECTIVE INSTRUCTOR-STUDENT COMMUNICATION, (2) DETERRING STUDENT PROCRASTINATION, (3) TRAINING IN THE ANALYTICAL PROCESS OF STUDY, AND (4) PROVIDING A FOUNDATION FOR ACTUAL PERFORMANCE OF THE EXPERIMENT AND SUBSEQUENT REPORTING. THE DOCUMENT CONTAINS A REPRODUCTION OF THE FORM. THIS ARTICLE IS PUBLISHED IN "IMPROVING COLLEGE AND UNIVERSITY TEACHING," VOLUME 13, NUMBER 2, SPRING 1965. (WO)

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A Tool for Independent Study in Biology

A form that stimulates and guides a student in independent laboratory study in biology is described by an instructor in biological sciences (A.B., M.A., California) of Sacramento City College. Use of the form, he says, has proved invaluable.

By JACK RICARD

SACRAMENTO CITY COLLEGE for a number of years has been providing its students with opportunities for independent study. In the biological sciences department emphasis has been placed upon a specialized version of independent study: selection, design, performance, and reporting of an experiment intended to evaluate an hypothesis formulated by the student through the use of the deductive approach from a self-selected topic. This program has been well accepted by students of all abilities and has proved quite effective in evaluating student performance. Some of the drawbacks experienced by many students as reported by Bonthius et al. (1957) were encountered at City College also: lack of effective guidance on the part of the advisor, tendency for the student to procrastinate. To overcome these drawbacks various approaches were tested. An effective one was found to be the SELECTION FORM. This form is made available to the students as soon as the course procedure is explained. It is to be returned to the instructor within two or three weeks after the start of the term. The selection form is as follows:

SACRAMENTO CITY COLLEGE—DEPARTMENT OF BIOLOGICAL SCIENCE
INDEPENDENT STUDY
EXPERIMENTAL METHOD EXERCISE—TOPIC SELECTION FORM

Name: ..... Course no.: ..... Date: .....

1. Title: .....
2. Reason for selection: .....
3. Hypothesis: .....
4. EXPERIMENTAL SUBJECTS. Kind: .....
   No. per group.....
5. VARIABLES. Independent: .....
   (STIMULUS) Unit:.....
   Dependent: .....
   (RESPONSE) Unit:.....
   Irrelevant*: .....
6. CONTROL GROUPS. Positive:..... Negative: .....
7. TEST GROUPS. I..... II. ..... III. .....
8. REFERENCES, include location where available:
   (1) .....
   (2) .....
9. EQUIPMENT and/or materials you cannot secure on your own: .....

* "Name two which may be significant here."

Use the back of the form for any comment or additional information you wish to include, AFTER CHECKING HERE:

.....

INSTRUCTOR'S COMMENTS:

.....

SELECTION REPORT DIRECTIONS

(Independent Study—Experimental Method Exercise)

1. Title: Should indicate what factor (independent variable) you are going to investigate on what characteristic (dependent variable) of what experimental animal(s). For example: "Effect of RNA on memory in rats."
2. Reason for selection: Three major approaches may be used here: (a) previous interest through personal experience of some sort, (b) current interest through review of other students' work or proposed experiments in BSCS manuals, "Research Problems in Biology for Students," (c) assigned experiment.
3. Hypothesis: what do you predict will be the effect of the independent variable on the dependent variable.
4. Experimental subjects. The selection of these depends on the independent variable primarily, also financial circumstances as well as home facilities. Some of the more convenient ones are: insects, planaria, microorganisms, barley seedlings, etc. The more traditional ones are rats. A limited number of these can be had from the College and the Junior Museum on a first come, first served basis. They can also be purchased from pet shops and laboratory supply houses at a cost of about $1 per rat. At least fifteen subjects are needed per experiment, at the rate of 3 per group, and 5 groups. Mice are also suitable in many cases and are slightly cheaper.
5. Variables. Three types of these have to be identified in connection with your topic: The independent variable (Stimulus), the dependent variable and at least two irrelevant variables. The independent variable is the factor which you predict is going to have some effect on the experimental subjects: vitamin on the growth rate of rats, sunlight on the growth rate of baby chicks, water on the growth rate of seedlings, etc.—to mention some of the simplest ones; or transaminase level in blood serum as a reflection of cardiac infarction, ribonuclease effect on learning transmission through cannibalism in planaria. It has to be measured in concrete units: mg/day, s.i.g. units, micrograms /ml, hours of exposure/day at given intensity level, ml/day. The dependent variable (Response) is concerned with the effect of the independent variable upon the experimental subjects. It must also be measured in concrete units: average weight per group in grams, height of seedling in cm, percentage of damaged tissue in the heart, percentage of conditioned response to stimulus. The irrelevant variables are those which may affect your results unintentionally: age, sex, and genotype are some of the more common ones. A more general way to define the term "variable" is: any magnitude which has different values under different conditions. In an experiment, the effort is to hold all such magnitudes constant except two, one which is given different known values (the independent variable), and the resulting values of the other

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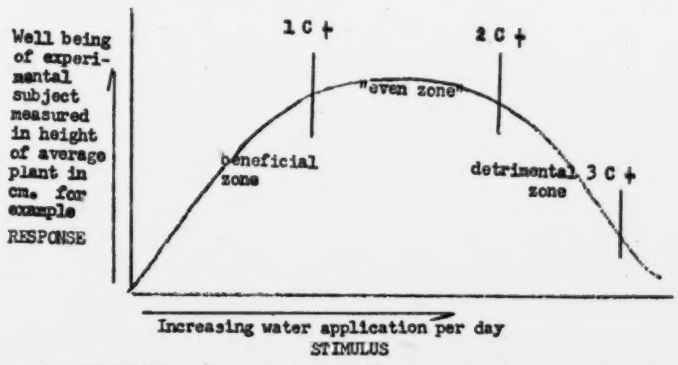
(the dependent variable) are observed and recorded. From these observations, the relationship between the two variables can be computed, unless results have been distorted by a third variable which has eluded control (the irrelevant variable).

6. The control groups are the extreme cases settling the limits within which you plan to test out the independent variable. Both are essential to reveal the characteristics of the experimental subjects under two extreme cases: (1) in the total absence of the independent variable in the environment (negative control or C–) and in the presence of an extremely large amount of the independent variable (positive control or C+). The function of the C– is self-explanatory. The C+ is essential in order to evaluate the area within which the experiment will take place. Almost any factor: physical, chemical or biological has an entirely different effect on experimental subjects depending on the level at which it is applied. The simplest example is perhaps the effect of water on barley seedlings (or rats, assuming forced feeding is used, as commonly performed on humans during the Dark Ages when torture was fairly common practice). The effect of water can be illustrated as follows:



A casual observation of the graph points out the extent to which the dependent variable response will vary as a result of the level of application of the independent variable. The same overall pattern prevails regardless of the independent variable used so that a positive control must be used in order to evaluate approximately where is the upper range of the independent variable located for the particular experiment you have designed: Within the "beneficial zone" as in the case of 1 C+, the "even zone" as in the case of 2 C+, or the "detrimental zone" as in the case of 3 C+.

The independent variable functions as the LIMITING FACTOR when its dosage is such that a change in its concentration results in a "beneficial zone" or "detrimental zone" pattern. Under those conditions a change in independent variable concentration is reflected immediately in the characteristics of the experimental subjects.

This concept of the limiting factor is a fundamental one in biology. Under all circumstances, individuals as well as populations are limited in their development by one factor. This factor may change quite rapidly from one moment to the next, but at any time there is always one and only one limiting factor operating.

If we are to follow the curve of the figure above from its point of origin at the intersection of the 2 axes, we find that the water supply is the limiting factor to the growth rate of the plant, until the "even zone" is reached; there, the dependent variable no longer responds to increases in independent variable concentration. Another characteristic of the environment has become the limiting factor then. As the water concentration increases still, the independent variable then exerts a harmful effect on the subjects and once more becomes the limiting factor. No population of any organism has learned to exert a self imposed limiting factor yet, this applies to man also, as shown by the present population explosion.

7. Test Groups. These are the three groups exposed to varying levels of the independent variable within the limits set by the C– and the C+. They should be fairly evenly spaced between these two extremes. Suppose the C– is 0 hours of sunlight per day and C+ is 24 hours of light per day, then test groups I, II, and III might well be respectively 6, 12, and 18 hours of sunlight exposure per day.

8. References. You should list there at least two sources *other than your textbook* which you have consulted in connection with the design of your experiment. These may be periodical articles or books. Periodicals should be listed in the following fashion: author's name, author's initials, year of publication, article title, periodical title, volume and page numbers. Book references should include: author's name, author's initial(s), year of publication, book title, publisher's name and address (city at least). These references may be secured through any of the three recommended procedures for topic selection: (a) You already have some interest in an area of biological sciences and have checked on recent developments in that area through the B.A.S.I.C. "key" to biological abstracts, the Biological Abstracts proper and the original publications located through the abstracts in that sequence. (b) You have developed some interest through review of proposed experiments in such manuals as are listed in the references; (c) you have been assigned an experiment and related reading by the instructor.

9. Equipment and/or materials you cannot secure. This is self-explanatory. Please rely on yourself as much as possible as little allowances are available so far for that purpose. Every effort will be made, however, to keep lack of facilities from preventing you to perform a valuable experiment.

Once the selection form is received by the instructor it is examined and given maximum credit (10 points) if properly filled, or returned to the student without any grade, but with specific suggestions for *correction by the student.* Once corrected the selection form is resubmitted, and the procedure described above repeated if necessary. In the returned papers the traditional bank policy is followed: "charge for extra handling," one point lost with each resubmission. When the selection form is completed properly the student proceeds with the actual performance of the experiment.

The use of the selection form has proven invaluable in various ways:

- **Effective communication between instructor and student as the attention of both is concentrated on the critical aspects of the experiment design. Oral communication is extremely valuable for psychological, often emotional reasons, but so far as concrete subject matter considerations are concerned this procedure appeared to be superior.**
- **Deterence of procrastination as an early deadline has to be met in completion of the first step in the independent study and increasing penalty associated with lack of attention.**
- **Training in the analytical process of study as independent, dependent and irrelevant variables have to be identified in a student chosen area.**
- **Effective foundation for the actual performance of the experiment and subsequent reporting of the work, using quantitative expression of the results in graphic and tabulated form.**

The selection form is the first of four formal assignments involved in the independent study part of the course, which includes also traditional presentation and test. The other three assignments are: the progress report, final report (with extra points allowed for use of a foreign language in whole or part) and oral presentation of the study to the class by the student.

REFERENCE

Bonthius, R. H. et al. Independent Study Programs in the United States. Columbia Univ. Press, 1967.

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The Editor's Uneasy Char

To read Dr Jerome Bruner's widely claimed "On Knowing is a heartening experience. Such a book has been for ye

The Credos of John and Jerome

overdue. One could only w for a book like it concern more especially with teaching at the colle and university level. It is gratifying to fin brilliant psychologist who has worked at frontier of his specialty interested practica in the application of psychology in educat and both discerning and lucid in his interp tations.

The book's excellence and timeliness exemplified in the chapter "After John Dew What?" The five basic points of Dewe 1897 Credo are briefly stated. Their 1962 placements as conceived by Bruner are pounded with the penetration and fascinati that characterize the whole book.

We know that Dewey's child-centered ucation was valid even though it led to surdities. We have not yet caught up w him, nor has he been cleared of the dama that misguided disciples committed agai him. The great gap between the conceptio of a prophet and the performance of his f lowers means a shadow over the figure Dewey as over many another in the history man. The placing of John Dewey in the p is a sobering fact to face.

While for Bruner the student is avowe a central concern throughout, the emphasis placed upon two principles: (1) "The str ture of knowledge—its connectedness and derivations that make one idea follow fr another—is the proper emphasis in edu tion." (2) "The unity of knowledge is to found within knowledge itself, if the kno edge is worth mastering." The pursuit o

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